VERIZON – INDOOR 911 LOCATION ACCURACY
IMPLEMENTATION PLAN AND PROGRESS REPORT
PS DOCKET NO. 07-114
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I.   INTRODUCTION

This document describes the relevant elements of Verizon's Implementation Plan (the "Plan") for meeting the Commission's rules for indoor location accuracy, together with the status of Verizon's progress toward meeting each element. Verizon's Plan incorporates many elements of the original Roadmap,[1] as adapted to the requirements of the rules and to developments in technology and policy that have arisen since the rules became effective. This Plan is necessarily a snapshot of Verizon's current intentions, objectives and progress. The Plan will need to evolve in response to improvements (and unforeseen shortcomings) in technology, and to the capabilities and plans of critical vendors in the communications ecosystem.

The Plan describes the various solutions Verizon intends to use and evaluate for its compliance. Verizon uses a number of methods to assess the performance of these various solutions to ensure they are reliable and will meaningfully contribute to Verizon's compliance and to PSAPs' and customers' needs. For currently deployed technologies, Verizon uses periodic empirical accuracy testing in representative call scenarios and locations to ensure the technologies are operating at optimum accuracy levels. Verizon also monitors weekly performance results to ensure that ongoing performance of live 911 calls remains consistent. Verizon's field engineering teams and technology vendors investigate and rectify (to the extent possible) any perceived underperformance. And it is Verizon's internal policy to review and test potential enhancements to our existing technologies and to evaluate new technologies that would measurably improve location performance, including field tests from challenging indoor location sites.

Finally, Verizon works closely and in good faith with public safety stakeholders through their national organizations, and industry standards committees, to ensure that the location information delivered over PSAP interfaces to PSAP call handling equipment is presented in a manner that is understandable and helpful for emergency dispatch. Those quality control measures and outreach efforts will apply to Verizon's indoor location accuracy enhancements as well.

II.   HORIZONTAL REQUIREMENTS

The Commission's rules for horizontal location are designed to give wireless service providers incentive to improve the percentage of wireless 911 calls over time that use technologies most likely to deliver highly accurate caller location information to PSAPs. Consistent with the general objectives of the Roadmap, Verizon's Plan is designed to meet these

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[1] Joint Letter of APCO International, Sprint Corporation, AT&T Services, Inc., T-Mobile USA, National Emergency Number Ass'n, and Verizon Wireless, PS Docket No. 07-114, Attachment A (filed Nov. 18, 2014) ("Roadmap").

requirements through a combination of technologies that will enable the delivery of either a "dispatchable location" or an x/y geographic coordinate within 50 meter accuracy. The rules allow the delivery of either dispatchable location or x/y location within 50 meter accuracy (as determined by Test Bed performance) to meet these requirements.

Service providers and other players in the communications ecosystem should plan and design services and products that accommodate the use of both dispatchable location *and* x/y location methods, and where possible should employ multiple reliable solutions to achieve both. Accordingly, while Verizon will endeavor to increase the proportion of dispatchable location fixes used to transmit data to PSAPs over time, the Plan's elements address both dispatchable location and x/y accuracy, and endeavor to use multiple solutions for each. Verizon also notes that while smaller service providers participating in its LTE in Rural America ("LRA") program will file their initial plans by this August, many of Verizon's indoor location accuracy implementation efforts will inure to those LRA participants' benefit as well.

A.   Dispatchable Location

National Emergency Access Database ("NEAD"). Verizon intends to begin using the NEAD as soon as possible after it becomes operational, currently targeted for January 2018. The concept behind the NEAD is fairly straightforward: when a caller dials 911 from a Wi-Fi- or Bluetooth-enabled handset, the service provider network will automatically collect information from the wireless handset about nearby low-power wireless access points within the caller's vicinity; the network, in turn, will query whether these wireless access points are in the NEAD database and associated with a verified street address plus additional location information as needed. If so, the wireless carrier network will determine which wireless access point street address information to provide as the 911 caller's dispatchable location.

Status. Verizon supported and participated in CTIA's effort to "stand up" NEAD LLC, the limited liability company that will administer and operate the NEAD. Verizon is directly supporting development and deployment of the NEAD through its pro rata share of financial support to NEAD LLC. Through its participation in the NEAD LLC's technical and steering committees, Verizon contributed to NEAD LLC's selection of ATIS in October 2015 as the NEAD program manager, and in October 2016, after a competitive bidding process, selected West as the vendor to develop and operate the NEAD. On November 3, 2016, after several months of working group effort (in which Verizon also participated), ATIS released the standard that defines the architecture and requirements for the NEAD, as well as how information in the database is processed.[2] Verizon also supported and participated in the development of the NEAD LLC Privacy and Security Policy being submitted under separate cover.

Verizon has undertaken internal efforts necessary to enable its network and customers' handsets to interact with and benefit from the NEAD. Verizon has initiated efforts to improve and update its wireless 911 location server to enable it to work with the NEAD once the NEAD

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[2] *See Location Accuracy Improvements for Emergency Calls* (ATIS-0700028 v1.1).

is operational. This is necessary to ensure that Verizon's network will appropriately process and prioritize location fixes from multiple location technologies (including dispatchable location), based on the accuracy and reliability of the fix. These measures also include implementing the LTE Positioning Protocol enhancements (LPPe) into Verizon's 911 server. This enhancement supplements the existing LPP standard and will allow devices to pass Wi-Fi access point information, Bluetooth beacon information, and Uncompensated Barometric Pressure information back to Verizon's network.

The NEAD solution also requires that LTE-enabled handsets transmit available Wi-Fi and other access point information to the service provider's network when the user calls 911. Verizon has incorporated this capability into the specifications for the handsets and underlying components (e.g. chipsets, operating systems) that it procures through the device ecosystem, and is working with those stakeholders to incorporate this capability into future handset model releases. The availability of dispatchable location to 9-1-1 callers may be limited, however, if OEMs do not embrace the NEAD functionality in their products. Finally, Verizon's wireless and wireline operations have collaborated to contribute the necessary information for millions of Verizon-maintained Wi-Fi access points to be populated in the NEAD database prior to its launch.

Consumer Home Products. While not in the Commission's rules, as part of their Roadmap commitments service providers voluntarily agreed to develop and introduce new wireless consumer home products that could provide additional methods of delivering dispatchable location independent of the NEAD.[3] Verizon plans to develop these solutions and offer them to customers in order to supplement wireless 911 callers' dispatchable location capabilities beyond what will be available to Verizon through the NEAD. In particular, Verizon will employ the E911 capabilities currently used for certain nomadic interconnected VoIP products to adapt them to LTE devices, with a particular focus on devices and services that consumers may use principally in residential and office environments.

Status. Verizon has incorporated this policy into its internal policies and practices for product development and device evaluation. Verizon has found that, in some cases, it will be able to leverage its existing vendor and network arrangements used for certain interconnected VoIP 911 calls and apply them to handset devices or other equipment that a customer principally uses at home or other indoor settings. Verizon is working with its E911 vendors to incorporate these capabilities into new products, some of which will enable delivery of dispatchable location to PSAPs. Verizon anticipates that some of these dispatchable location-capable devices may become available to its customers during 2017.

Small Cell Positioning Solutions.   When deployed for indoor use, the lower power facilities of certain small cell configurations, and the resulting well-defined coverage, will provide service providers with another source of dispatchable location information for PSAPs for many 911 calls, also independent of the NEAD. In essence, service providers will be able to

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[3] Roadmap at 4.

adapt the fixed address associated with "Phase 1" cell site location to a dispatchable location in many cases. Verizon will include reliable small cell-based solutions in its toolbox of solutions.

Status. Verizon has incorporated E911 location capabilities into its product and network specifications for promising small cell technologies. Verizon is currently focused on Enterprise Radio Access Network ("E-RAN") based solutions. With these solutions, each antenna node would have both its own x/y coordinates and also can provide PSAPs a dispatchable location when the service provider is able to associate the E-RAN facilities with a particular civic address. Verizon has worked with its E911 vendors to incorporate these capabilities into its E-RAN architecture, which for many 911 calls will enable delivery of dispatchable location to PSAPs. Verizon has begun deploying the capabilities where E-RAN is also deployed. And through ATIS ESIF, Verizon was actively involved in the development of standards for testing of small scale location technology deployments.

B.   Improving the Accuracy of X/Y Coordinates.

In addition to incorporating dispatchable location capabilities into its network and consumer products, Verizon will improve the accuracy of x/y coordinates delivered to PSAPs by supplementing its existing Assisted-GPS ("A-GPS") solution already deployed ubiquitously throughout its CDMA and VoLTE networks.

Test Bed. Service providers, consumers and PSAPs will benefit from a variety of available viable location solutions. Verizon thus supports implementation and ongoing operation of the location accuracy Test Bed beyond the bare minimum needed to meet its regulatory obligations. Accordingly, where feasible and appropriate, Verizon will support the testing of E911 location solution vendors' technologies through its network and personnel resources.

Status. Service providers have established an independent Test Bed, modeled on stakeholders' experience under the Commission's CSRIC III and CSRIC IV, that will assess how different wireless 9-1-1 location technologies and solutions perform against the indoor location accuracy rules. Verizon supported and participated in CTIA's effort to "stand up" Test Bed LLC, the limited liability company that will administer and operate the Test Bed. Verizon is directly supporting the startup and maintenance of the Test Bed through its pro rata share of financial support to Test Bed LLC. Test Bed LLC selected ATIS as the Test Bed program manager and in March 2016, Test Bed LLC selected LCC Design Services, a Tech Mahindra Company, to administer and execute the Test Bed.

Verizon has also contributed to the establishment of testing specifications through its participation in the ATIS Emergency Services Interconnection Forum (ESIF), thus giving the Test Bed the imprimatur of an ANSI-accredited standards process. ATIS ESIF has also established procedures to ensure orderly testing of service providers' existing location accuracy solutions and technology vendors' new solutions, as well as guidelines on test building and test

point selection. And Verizon supports all these efforts through its co-chair position on Test Bed LLC's Technical Advisory Committee (TAC).

The Test Bed was completed prior to the August 2016 compliance date, has completed two stages of testing. Stage one included the four nationwide service providers. Stage 2 has involved at least four solution vendors: NextNav; Polaris; Nokia HERE; and TruePosition/ SkyHook. And a third stage of testing involving service providers is ongoing. Verizon has completed or nearly completed testing of the components of the A-GPS solution it currently uses for its legacy CDMA network (GPS, hybrid, and AFLT) the A-GPS solution used for its LTE network, and the OTDOA solution that will supplement A-GPS for Verizon's LTE network. And as discussed below, Verizon has also sponsored two different vendors' tests of X, Y *and* Z-Axis technology in the CTIA 911 Indoor Location Test bed – NextNav and Polaris Wireless.

Observed Time Difference of Arrival (OTDOA). Verizon will use OTDOA instead of AFLT (currently used for CDMA) as the network-based fallback location technique when a satellite-based location fix is unavailable and the handset is in LTE coverage. OTDOA uses highly detectable Position Reference Signals ("PRS") to estimate the caller's location. It is designed to outperform AFLT both indoors and outdoors due to higher LTE bandwidth, improved hearability (*i.e.*, the handset's ability to obtain distance measurements from multiple base stations), and more advanced processing. OTDOA should continue to improve as Verizon deploys additional LTE cell sites for capacity, notably in the very urban areas where indoor accuracy challenges are particularly acute.

Status. Verizon has deployed OTDOA across its entire LTE footprint, covering tens of thousands of its eNodeB base stations. OTDOA deployment entailed a number of significant steps, including: precise measurements of cable delays; hiring of professional surveyors to obtain accurate latitude/longitude measurements of LTE antennas; and improvements in Verizon's cell site database to improve OTDOA's effectiveness. Verizon has undertaken several rounds of proof of concept testing with its vendors and will complete testing in the Test Bed in the near future.   In addition, Verizon is working on implementing a number of enhancements to OTDOA. Through "PRS Muting," for example, the network manages the base station to stagger the broadcast of cells that transmit PRS in order to reduce inter-cell interference and improve the accuracy of the location fix. This method is currently up and running in two markets and will be deployed nationwide in the near future.

Another method of enhancing OTDOA is so-called "Inter-Frequency" capability, through which OTDOA can collect PRS measurements on multiple spectrum frequencies and bands, regardless of whether the 911 caller's handset is using those bands. This enables more cells to be detected and thus improves the accuracy of the location fix. Verizon has initiated field tests of Inter-Frequency OTDOA and tentatively plans to deploy it nationwide in 2017. Finally, OTDOA Assistance Data is yet another enhancement designed to increase the number of cell sites that can be used for an OTDOA location fix. Verizon has conducted initial testing of this enhancement and is currently working with vendors to refine it further.

*Crowd Sourced Wi-Fi Positioning***.** Verizon will work with vendors and other players in the communications ecosystem to incorporate crowd sourced Wi-Fi positioning methods into its E911 location accuracy solution. These solutions will leverage solutions already used for commercial location-based services by providing handsets with yet additional position sources to improve the accuracy of x/y information transmitted to PSAPs. Verizon will work with other stakeholders to adapt these technologies to the 911 environment to ensure the reliability of the information and the seamless availability of the solution to consumers.

Status. Verizon is deploying a crowd sourced Wi-Fi positioning solution in its 911 wireless database server. Verizon conducted (and completed) a rigorous RFP, requiring the submission of indoor location test results, to select a reputable Wi-Fi crowd sourced solution. This technology is expected to improve 911 location accuracy in all areas, but particularly indoors and in urban canyons where Wi-Fi access points have proliferated. The solution is scheduled to be operational during late 2017. The solution will require handsets to transmit information on Wi-Fi signals that they see back to the Verizon network, so that the location of those access points can be used to generate the x/y information to transmit to the PSAP. Additional cooperation with OEMs and other stakeholders in the device ecosystem will be necessary to maximize the number of consumers that will benefit from this solution and such cooperative efforts are currently under way.

Assisted GNSS. Verizon's A-GPS solution currently uses one GNSS satellite constellation for E911 location accuracy, the U.S. government-operated Global Positioning System (GPS). Enhancing A-GPS through the addition of additional GNSS constellations will help improve the accuracy of satellite-based location fixes, including for indoor 911 calls in many cases. While this capability could be easily implemented for 911 purposes today, the Commission's *Fourth Report and Order* has precluded use of this enhancement pending further testing and U.S. government coordination to address broader issues concerning the use of non-U.S. GNSS constellations. Verizon will pursue the necessary testing and government coordination efforts in order to use additional GNSS satellite constellations for 911 location accuracy.

Status. Verizon is actively working with other service providers, OEMs, chipset vendors, and the Commission and other US government agencies, to develop a testing program to address issues concerning the use of non-US radionavigation satellite systems. Nevertheless, Verizon hopes that the necessary government coordination efforts needed to enable service providers and their vendors to use non-US GNSS satellite constellations for 911 location accuracy purposes could enable use of those systems in late 2017 or during 2018.

Device Based Hybrid (DBH). Verizon's Plan includes the use of viable DBH solutions. With a DBH-based solution, the handset uses both satellite (GPS) information and Wi-Fi based information to generate a highly accurate x/y coordinate to transmit to PSAPs. The DBH solution will enable the handset to transmit this so-called "Mobile Station Based" (MSB) location, as well as the measurements for the "Mobile Station Assisted" (MSA) location

(including A-GPS) back to the 911 server. The server, in turn, will choose the better of the two x/y location estimates to send to the PSAP.

Status. Verizon has incorporated DBH functionality into its 911 location server and performed initial testing of DBH on its network. In particular, Verizon has tested several forms of Mobile Station Based (MSB) positioning technology to see how well this solution works indoors and the results are promising. Verizon is working with OEMs and others to incorporate DBH functionality (and MSB in particular) into the suite of 911 location solutions available to 911 callers and PSAPs. While Verizon believes that handsets with DBH capability should support both MSA- and MSB-derived location fixes, the availability of that capability for particular devices may depend in part on OEMs' policies as well.

III.   VERTICAL LOCATION ACCURACY REQUIREMENTS

The Commission's requirements for vertical location accuracy are designed to give wireless service providers incentive to deploy solutions that deliver a 911 caller's vertical location to those geographic areas where 911 callers are more likely to benefit from those capabilities. Service providers may comply with these requirements through two alternative means: maintaining a sufficient number of dispatchable location access points in the most populous service areas; or deploying an accurate vertical "Z-axis" solution across sufficient coverage within those service areas. In addition to pursuing dispatchable location solutions through the NEAD and other methods, Verizon is working with vendors and taking internal steps to facilitate the development and possible use of viable Z-axis solutions as well.

A.   Uncompensated Barometric Data

The rules require that by August 2018, wireless providers "make uncompensated barometric data available to PSAPs with respect to any 911 call placed from any handset that has the capability to deliver barometric sensor information." As noted, Verizon is currently implementing the LPPe protocol in its 911 server, which will enable a handset to transmit available Uncompensated Barometric Pressure (UBP) on the device back to Verizon's network for delivery to the PSAP. In addition, to use UBP it is necessary to install new software on Verizon's 911 server. This software will parse the LPPe message from the handset and extract the UBP reading to send to the PSAP. Verizon has initiated the necessary measures to install this software on its 911 server.

B.   Dispatchable Location

Dispatchable location, by definition, will include vertical information where needed (e.g. the floor, suite, etc., of the 911 caller). Thus, all of the measures described above relating to development and deployment of technologies and solutions for dispatchable location are also attributable to Verizon's efforts to comply with the Commission's vertical location accuracy rules. Note that while the Commission's rules require dispatchable location availability in the top 50 cellular market areas (CMAs), the dispatchable location information available to service

providers and PSAPs via the NEAD, consumer home products, and small cell technologies will not be so geographically limited.

C.   Z-Axis Vertical Requirements

Verizon supports the development and testing of new Z-axis solutions and continues to evaluate them for viability. As noted earlier, Verizon sponsored two different vendors' tests of Z-Axis technology in the Test Bed – NextNav and Polaris Wireless. Another round of testing in the Test Bed is scheduled for this year, a part of which will focus on testing the performance of Z-axis solutions. Participating stakeholders will make a decision on the appropriate metric for vertical location accuracy largely based on the results from this next stage of testing. Verizon continues to support ATIS ESIF as Chair and was actively involved in the development of standards for Z-Axis testing, and is co-chair of CTIA's Z-Axis Working Group. Finally, many of the efforts that Verizon is supporting or implementing to ensure its compliance with the horizontal location accuracy rules will facilitate implementation of Z-axis solutions as well, including creation and maintenance of the Test Bed and implementation of the LPPe protocol.

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